Ecology: A Primer for Christian Ethics

Holmes Rolston, III

"Ecology" is, etymologically, the logic of living creatures' homes. Christian ethicists find the word suggestively related to "ecumenical," with common roots in the Greek "oikos," the inhabited world. Biology has developed at two main levels: (1) organismic, which is popularly put as "skin-in" biology, and (2) evolutionary-ecosystemic, the latter is "skin-out" biology. Organismic biology, especially at cellular and molecular levels, has been on a fifty-year high, with spectacular successes in medicine, unraveling the genetic code, biotechnology, and so on. Evolutionary biology has profoundly redescribed the world and relocated humans within it; the last century was Darwin's century, his ideas reshaping everything we think in biology.

By comparison, ecology is often thought to be a less mature science, for all its importance. Ecosystems are complicated and messy, hard to do experiments on; they are open systems that resist analysis. Still, in the last three decades, ecology has been thrust into the public arena. With the advent of the ecological crisis, then-Secretary of Interior Stewart Udall testified to Congress: "We must begin to work with, not against, the laws of the planet on which we live. . . . This requires that we begin to obey the dictates of ecology, giving this master science a new and central position in the federal scientific establishment."[1] Congress in *The National Environmental Policy Act* expects that the ecological sciences can help the nation "to create and maintain conditions under which man and nature can exist in productive harmony."[2]

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[1] Quoted in *House Committee on Science and Astronautics*, 90th U.S. Congress, 2nd session, *Colloquium to Discuss a National Policy for the Environment*, p. 12, p. 14, Committee Print, 1968.

[2] 83 Stat. 852, Sec. 101(a). Public Law 91-190.

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An ecological ethics mixes how the natural world is with how humans ought to behave in it, mixing science and conscience, often with this suggestion that humans ought to find a lifestyle more respectful of, or harmonious with, nature. Ample numbers of Christian theologians and ethicists have felt that religion too needs to pay more attention to ecology, and perhaps also vice versa. Examples are John B. Cobb, Jr., *Is It Too Late: A Theology of Ecology,*[3] Sallie McFague, *The Body of God: An Ecological Theology,*[4] and Rosemary Radford Reuther, *God and Gaia.*[5]

There are both problems and opportunities when Christian ethicists look toward ecological science and wonder what (use) to make of it. An environmental ethic is foolish not to be informed by the best such science available. The success of an environmental policy does not depend merely on the cultural values, the policy preferences, or the social institutions that drive the human actors. Success depends on coupling such prescriptive values with an environmental science that is descriptively accurate and operationally competent. On the other hand, there are many pitfalls and one has to proceed cautiously. We offer here only a primer.[6]

1. Ecology and evolution

The British Ecological Society asked their members for the most important ideas in ecology.[7] The results, from nearly 650 ecologists, convey a sense of basic concepts, as well as a diversity of ideas, even to those unfamiliar with the detail. See Figure 1.

Any account of ecology has to locate itself within a general picture of natural history, tracing the origin of life and its subsequent speciation on Earth over some 3.5 billion years. Although natural selection for survival of the best adapted, is, in Darwinism, the chief determinant of evolutionary processes, biologists are increasingly convinced that other considerations include genetic drift (which natural selection can't "see"), founder effects (atypical gene frequencies in initial colonizing populations), environmental constraints (such as changing climates), or

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[3] Beverly Hills, CA: Bruce, 1972.

[4] Minneapolis: Augsburg Fortress Publishers, 1993.

[5] San Francisco: HarperSanFrancisco, 1992.

[6] These questions are further explored in Holmes Rolston, III, *Conserving Natural Value* (New York: Columbia University Press, 1994) and *Environmental Ethics* (Philadelphia: Temple University Press, 1988).

[7] J. M. Cherrett, "Key Concepts: The Results of a Survey of Our Members' Opinions," pages 1-16 in J. M. Cherrett, ed,. *Ecological Concepts* (Oxford: Blackwell Scientific Publications, 1989).

Most Important Ideas in Ecology The British Ecological Society (1988)

1. The ecosystem
2. Succession
3. Energy flow
4. Conservation of resources
5. Competition
6. Niche
7. Materials recycling
8. The community
9. Life history-strategies
10. Ecosystem fragility
11. Food webs
12. Ecological adaption
13. Environmental heterogeneity
14. Species diversity
15. Density dependent-regulation
16. Limiting factors
17. Carrying capacity
18. Maximum sustainable yield
19. Population cycles
20. Predator-prey interactions
21. Plant-herbivore interactions
22. Island biogeography theory
23. Bioaccumulation in food chains
24. Coevolution
25. Stochastic processes
26. Natural disturbance
27. Habitat restoration
28. The managed nature reserve
29. Indicator organisms
30. Species exclusion (Gause)
31. Trophic level
32. Community patterns
33. r and K selection (1)
34. Plant animal coevolution
35. Diversity-stability hypothesis
36. Socioecology
37. Optimal foraging
38. Parasite-host interactions
39. Species-area relationships
40. The ecotype
41. Climax
42. Territoriality
43. Allocation theory
44. Intrinsic regulation
45. Pyramid of numbers
46. Keystone species
47. The biome
48. Species packing
49. The 3/2 thinning law (2)
50. The guild

(1) Deals with differing reproductive strategies, with disturbed environments favoring r-selected species, climax environments favoring K-selected species.

(2) Deals with the patterns of natural thinning when a regenerating forest, first crowded with young trees, matures.

Figure 1.

catastrophic extinctions (caused by collisions with asteroids). Many think that natural selection does not explain the increasing complexity, or even the diversity, over evolutionary time, that is, the macroevolution (trilobites becoming dinosaurs) contrasted with the microevolution (hair becoming white in cold climates). A current fashion is to emphasize the role of contingency or even chaos.

Meanwhile, other biologists incline to see the evolutionary nature as a self-organizing system. A word lately coined by Humberto R. Maturana and Francisco J. Varela is "autopoiesis" *(autos, self*, and *poiein*, to produce).[8] Stuart Kauffman concludes a long study of the origin of order: "We may have begun to understand evolution as the marriage of selection and self-organization."[9] Though now put forward in secular form, the idea, as those versed in the Bible will realize, is an old one: "The earth produces of itself (Greek: *automatically)*" (Mark 4.28). At a deeper level, of course, Bible writers held that this is because of the divine fiat: "Let the earth bring forth living creatures according to their kinds"' (Genesis 1.24). The "auto" posits an innate principle of the origination of order, or genesis, similar to that present etymologically in "nature."

The incorporation of chaotic elements across evolutionary history has taken an interesting turn. Analyzing computer, mathematical, and biological models, Kauffman finds that natural selection can drive ordered systems to the edge of chaos because that is where the greatest possibility for self-organization, and survival in changing environments, occurs, "Evolution has tuned adaptive gene regulatory systems to the ordered region and perhaps to near the boundary between order and chaos." "Networks on the boundary between order and chaos may have the flexibility to adapt rapidly and successfully."[10] In these "poised systems" creativity is entwined with chance and chaos. The construction of order is most probable at the edge of disorder. "Such order has beauty and elegance, casting an image of permanence and underlying law over biology. Evolution is not just 'chance caught on the wing." It is not just a tinkering of the ad hoc, of bricolage, of contraption. It is emergent order honored and honed by selection."[11] Geneticists and evolutionary biologists have come to speak of "natural genetic engineering." "Thus, just as the genome has come to be seen as a highly sophisticated information storage system, its evolution has become a matter of highly sophisticated information processing."[12]

Systematists in biology do not know how many species have been generated by such processes on Earth, with species estimates recently

[8] Humberto R. Maturana and Francisco J. Varela, *Autopoiesis and Cognition: The Realization of the Living* (Dordrecht/Boston: D. Reidel Publishing Co., 1980).

[9] Stuart A. Kauffman, "Antichaos and Adaptation,[3]' *Scientific American* 265(no. 2, August, 1991): 78-84, summarizing his *The Origins of Order: Self-Organization and Selection in Evolution* (New York: Oxford University Press, 1993).

[10] Kauffman, "Antichaos."

[11] Kauffman, *Origins of Order,* p. 644.

[12] James A. Shapiro, "Genome System Architecture and Natural Genetic Engineering, pages 1-14 in Laura F. Landweber and Erik Winfree, eds., *Evolution as Computation* (New York: Springer-Verlag, 1998), citation on p. 10. See also James A. Shapiro, "A 21st Century View of Evolution: Genome System Architecture, Repetitive DNA, and Natural Genetic Engineering," *Gene* 345(2005):91-100.

revised upwards from some 5 to 30 or even 100 million, with only some 1.5 million actually described by taxonomists.[13] Also it has proved important to realize that a species count is not the only, and, in many cases, not the best indicator of biodiversity. In general, without ceasing to think that species are important, analysis and debate has tended in recent years to focus on biodiversity at all levels (different kinds of. ecosystems, or alleles within populations).[14]

2. Ecosystem dynamics

The mixture of order and disorder in ecosystems has been much discussed, and revised, partially in view of the changing views on order and disorder. Early ecologists, at least within the time frames of their analysis, usually a few years or decades, favored ideas such as stability, homeostasis, equilibrium. Ecosystems had various feedback and feedforward loops, checks and balances, that tended to be self-regulating; population densities were controlled by rainfall, or parasites, or predators, or prey, and these were statistically analyzable. These were superimposed on succession. Later ecologists, perhaps because of longer time frames, have interpreted ecosystems as much more open, unstable, even chaotic,

Perhaps this can be ecosystem-specific. Some ecosystems can be *constant*, that is, little changing in some dimensions. Temperatures change rather little in some tropical forests; species richness or evenness may remain about the same. Some ecosystems may be *persistent*, that is, last long periods of time with little changes in species and their interrelationships. Ecosystems may have *inertia*, that is, resist external perturbations; this will probably be because of negative feedback loops that dampen changes, such as density dependent reproduction regulated by food supply or competition or parasites and diseases.

Ecosystems may be *elastic;* if so, they return rapidly to their former state after perturbation. This may depend on the *amplitude* of the perturbation, both the area disturbed and the degree of displacement. Ecosystems sometimes have *cyclic stability*, that is, oscillate periodically about some central mean, or they may have *trajectory stability*, that is, move steadily along routes of succession or, more vector-like, have his-

[13] Robert M. May, "How Many Species Are There on Earth?" *Science* 241(1988):1441-1449.

[14] Edward O. Wilson, *The Diversity of Life* (Cambridge, MA: Harvard University Press, 1992).

torical tendencies.[15] Ecosystems may be cycles on cycles at close hand but, over longer times, spirals that stretch out directionally, or search systems that select for organisms that can explore new niches. The stability of ecosystems is a dynamic stability, not a frozen sameness, though there are some perennial givens—wind and rain, soil and photosynthesis, competition, predation, symbiosis, trophic pyramids and networks.

Ecosystems can undergo successions, and be periodically rejuvenated. Ecosystemic succession—disturbance, early succession, mid-succession, late succession, and climax—is a widely embraced theory; but, depending on how frequent and extensive these interruptions are, succession can be more ideal than real. Ecosystems have their tendencies of development, after disturbance; but, if often enough interrupted, they wander though contingencies as much as do they steadily develop. Such ecosystems may wander within bounds. Or, they may be stable within bounds, but, when unusual disturbances come, with enough amplitude to knock them out of bounds, they are displaced beyond recovery of their former patterns. Then they wander until they settle into some new equilibrium. There is no one and only stable state that an ecosystem should always have. Ecosystems are always on historical trajectory.

Some interpreters have used this to conclude that human environmental policy cannot be drawn from nature; we humans will have to step in with our management objectives and re-shape the ecosystems we inhabit accordingly, bringing them into some new equilibrium consonant with our cultural goals. But of course that assumes that ecosystems have enough regularity and predictability to be managed. Even Daniel Botkin, quite insistent that ecosystems have no stability, finds that he can make good computer models of ecosystems, useful for prediction and management.[16]

Lately, with the popularity of chaos theory, some ecologists insist that ecosystem histories are more random walk than they are stable dynamisms. Against the sheer random walk hypothesis, there is no doubt that ecosystems are full of cybernetic subsystems, for example, the

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[15] Gordon H. Orians, "Diversity, Stability and Maturity in Natural Ecosystems." Pages 139-150 in W. H. van Dobben and R. H. Lowe-McConnell, eds., *Unifying Concepts in Ecology* (The Hague: Dr. W. Junk B. V. Publishers, 1975).

[16] Daniel B. Botkin, *Discordant Harmonies* (New York: Oxford University Press, 1990).

species lineages that transmit information over time, generation after generation. There is variation, but selection requires relative stability in environments. A rabbit with a lucky genetic mutation that enables it to run a little faster has no survival advantage to be selected for, unless there are foxes and coyotes reliably present to remove the slower rabbits.

Some events are more infrequent: extreme droughts or storms. Coded in the genetics and expressed in the coping behaviors of its member species, ecosystems will have the capacity to adjust to interruptions that come often enough to be remembered in the genetic memory. Provided that climatic changes, or novel species, are not too overwhelming, ecosystems that have long persisted will probably persist longer.

Nevertheless, there is dynamic change, and the dynamic changes through time yield historical development. Integrity in ecosystems includes the capacity to evolve. Stability, and nothing more, would squelch this creativity. On a big enough scale, ecology does meet evolution. Or, perhaps one should say, the evolution going on all the time becomes evident. Historical change is made possible by stability that supports variation. The result is the rich generation of biodiversity and biocomplexity on Earth.

Ecologists do not have much grand theory, laws that are always and everywhere true all over the Earth, seemingly because of this change and openness in ecosystems. Jonathan Roughgarden remarks: "It is difficult to imagine what could ever qualify as a 'law' in ecology."[17] What grand theories they have—for example, the Lotka-Volterra equations, which relate population size, the number of organisms that the environment will support, to time, growth rate, and carrying capacity—initially seem important, but turn out to be such gross simplifications that they are of little help in understanding actual landscapes. They are true but abstract so greatly from particulars, that they leave "the devil in the details." Using any such laws of ecology to understand the Chesapeake Bay is something like trying to use the laws of gravity or survival of the fittest to explain the outcome of a presidential election.

So a frequent complaint is that ecological theory is too grand to be of much use in the field, and especially not very useful if cultural determinants (the price of oil in the Middle East) are likely to affect what is

[17] Jonathan Roughgarden, "Competition and Theory in Community Ecology," *American Naturalist* 122(1983):583-601, citation on p. 597.

going on in natural systems (agriculture in the Midwest, where one is trying to keep soil enough for a healthy ecosystem). Ecology is a "piecemeal" science that can, at best, be good at generalizations of regional or local scope. Perhaps the most ecologists can do is to have what Roughgarden calls a "collection of tools"[18] (such as eutrophication of lakes, keystone species, nutrient recycling, niches, succession, or others of the fifty concepts) and put some of these to work in the particular circumstances at hand.[19]

Meanwhile, it is increasingly true that an ecosystemic nature, once flourishing independently of humans, is today under threat owing to human disruptions. This threat is variously described as a threat to ecosystem function, health, integrity, or quality. Biological *integrity* is the ability of an ecosystem to support and maintain "a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region."[20]

Biological *health* is the state in which the genetic potentials of an ecosystem's member species are being realized as organisms flourish in their niches, these interrelated in such way that the systemic condition is dynamic and stable, the systemic capacity for self-repair when perturbed is present, and there is needed only minimal outside management. "An ecological system is healthy and free from 'distress syndrome' if it is stable and sustainable—that is, if it is active and maintains its organization and autonomy over time and is resilient to stress"[21] Biological *integrity* has as a baseline index the ecosystem that was originally there, the natural history, while biological *health* may, but need not always, require species that were originally there. There may be culturally-introduced replacements. If there is health, these replacements will thereafter function with minimal management intervention.

Without people around, ecosystems seem to be usually healthy and to have their integrity. The processes and products originally in place,

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[18] Ibid, p. 597.

[19] Kristin Shrader-Frechette and Earl D. McCoy, *Method in Ecology: Strategies for Conservation* (New York: Cambridge University Press, 1993); R. H. Peters, *A Critique for Ecology* (New York: Cambridge University Press, 1991).

[20] James R. Karr and D. R. Dudley, "Ecological Perspective on Water Quality Goals," *Environmental Management* 5(1981):55-68.

[21] Robert Constanza, Bryan G. Norton, and Benjamin D. Haskell, *Ecosystem Health: New Goals for Environmental Management* (Washington, DC: Island Press, 1992), p. 9.

independently of humans, will with high probability have naturally selected species for their adaptive fits, since misfits go extinct and unstable ecosystems collapse and are replaced by more stable ones. Ecosystems get tested over thousands of years for their resilience. This is true even though from time to time in the past, natural systems were upset (when volcanoes exploded, or tsunamis destroyed them, or catastrophic epidemics broke out), and integrity of ecosystems then had to re-evolve. Natural systems are typically places of adapted fit, as evolutionary and ecology theory both teach.

Ecology as a science has not proved immune from the postmodernist and deconstructionist claims that science in all its forms—astrophysics to ecology—is a cultural construct of the Enlightenment West, more pragmatic in enabling scientific cultures to get what they want out of nature than descriptive of what nature is really like, absent humans and their biases and preferences. Sophisticated epistemologists will abandon the myth of "the mirror of nature."[22] All we can see is nature with a human face. Those who press this account find that there is no single unified science called ecology, with settled descriptions of what ecosystems are like in themselves, but various ecologies that serve various purposes of their users.

Test yourself, for instance, to see what preposition goes in the blank: "Ecologists should not seek to understand objectively how nature works in itself; they should seek a knowledge that will help society to protect the environment______efficient use and exploitation." Whether you insert *for* or *from* depends on no science, but on your value commitments. Advocates of this or that use of, or relationship to, nature look for the support of ecology to pursue whatever interests they have at stake. Fortunately, or unfortunately, ecological science is open-ended enough that by shifting one's emphases and judgment calls on the weight of evidence, differing parties will all be able to appeal to ecology on their behalf. The preservationists, for example, stir up alarm about imminent global warming; the industrialists, meanwhile, employ different ecologists who can argue away the problem, or environmental engineers who can promise a technological fix.

On this postmodernist view, we humans should make no pretensions to know what nature is like without us, but we can choose what it is like to be with nature, living harmoniously with it, which will result in

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[22] Richard Rorty, *Philosophy and the Mirror of Nature* (Princeton, NJ: Princeton University Press, 1979).

a higher quality life. All we can do is live out our story, and that will be interactive with *our* ecology (contrasted with some unknown trans-human ecology). We humans are earthlings as well as citizens, and environmental ethics is about *our* sense of place. This fits well with a bioregional perspective; environmental ethics is going to have to work in the Chesapeake Bay area, or the Desert Southwest, or the Pacific Northwest. People take up a relationship to their landscapes; environmental ethics is as much applied geography as it is pure ecology.

3. Ecosystem management

A recent emphasis has been ecosystem management. This promises to combine what ecosystems are, scientifically, with what we humans wish to do employing them in our cultural stories. This way of putting it has an appeal alike to the scientists, who see the need for understanding ecosystems objectively, and also to the developers, who like the word "management." Further, this seems balanced to politicians and environmental policy-makers, since the combined ecosystem/management principle promises to operate at the system-wide level, presumably to manage for indefinite sustainability, alike of ecosystems and their outputs for human benefit. Such management connects with the idea of nature as "natural resources" at the same time that it has a "respect nature" dimension.

Ecosystem management has been criticized as an umbrella idea under which different managers can include almost anything they wish, since what one is to manage ecosystems *for* is left unspecified. They might manage for maximum sustainable yield, or for equal opportunity in the next generation, or for maximum biodiversity, or for quick profit. Nevertheless there usually is the idea of fitting human uses into an ongoing ecosystem health, or integrity. This is often a matter of managing humans uses of their ecosystems with as much care as one is managing, or revising, wild nature.

Five goals of ecosystem management are:

1. Conserve viable populations of native fauna and flora.

2. Conserve representative ecosystems.

3. Conserve ecological processes, including natural disturbance regimes.

4. Conserve the evolutionary potential of species and ecosystems.

5. Accommodate human uses within these goals.

Humans can only flourish if they live where their ecosystems are functioning well. There is cycling and re-cycling of energy and materials; the member organisms too are flourishing as interrelated fits in their niches. The system is spontaneously self-organizing in the fundamental processes of climate, hydrology, photosynthesis. There is resistance to, and resilience after, perturbation. The system does not have constantly to be doctored. Aldo Leopold said: "Health is the capacity of the land for self-renewal. Conservation is our effort to understand and preserve this capacity."[23]

Unhealthy system will have "reduced primary productivity, loss of nutrients, loss of sensitive species, increased instability in component populations, increased disease prevalence, changes in the biotic size spectrum to favor smaller life-forms, and increased circulation of contaminants."[24] Monocultures have little health. Pushed more and more into artificiality, there is really no ecosystem left at all. A cornfield two miles square is almost like a twenty-acre parking lot full of cars. The individual corn plants might be healthy enough, but they are just parked there by humans, about like potted plants on the porch. There are hardly any ecosystemic connections at all, past the sunshine. Even the fossil water is pumped from a half mile below.

Highly modified once-natural systems, now requiring steady management, such as farmlands, which must be plowed, seeded, fertilized, harvested each year, cannot be said to have native biological integrity. They can perhaps have some kind of agricultural integrity, if they can be managed sustainably, and if their operation does not disrupt the surrounding natural systems (rivers, forests, native fauna and flora in the fencerows, edges, fallow fields, pastures, rangelands). Areas put into agriculture, or industry, or to urban uses, will always have to enveloped by natural systems. Else the system will crash.

A properly managed ecosystem will protect natural values, as well as support cultural values, and such productivity and support is the bottom line for an environmental ethic. Here we can take ecosystem integrity and health not just as theoretical ideas; they become symbolic; we can also use them to guide specific research and policy strategies.

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[23] Aldo Leopold, *A Sand County Almanac* (New York: Oxford University Press, 1968), p. 221.

[24] David J. Rapport, "What Constitutes Ecosystem Health?" *Perspectives in Biology and Medicine* 33(1989): 120-132, citation on p. 122.

We set pollution standards, for instance, above which threshold there is evident deterioration of fish and waterfowl reproduction. Dissolved oxygen may not fall below 5 milligrams per liter in coldwater fisheries. We can study the food chains, measure energy cycling and materials recycling, measure population rises and falls, recovery rates, and so forth, to find out, scientifically, what interconnections constitute and preserve biological integrity.

The 100% natural system no longer exists anywhere on Earth, since there is some DDT in penguins in Antarctica. Perhaps ninety-five percent of a landscape will be more or less rebuilt for culture, considering lands plowed, grazed, forests managed, rivers dammed, and so on. Still, only about twenty-five percent of the landscape, in most nations, is under permanent agriculture; a large percentage is more or less rural, mixedly interrupted and still with some processes of wild nature taking place there. Over the Earth's vegetated land surface, about 63.7% of the land is either little disturbed (27.0%) or only partially disturbed (36.7%), with only 36.3% human dominated.[25] So, humanly managed and rebuilt though nature is, nature is still there.

How much naturalness is or ought to be present on a landscape? Consider the following criteria:

(1) What is the historical genesis of processes now operating on the landscape? Were they introduced by humans, or do they continue from the evolutionary and ecological past? The more doctoring, the less likely there is health.

(2) What is the species constitution compared with the original makeup? The more the fauna and flora is depauperate, the less integrity and health.

(3) How much cultural energy is required for the upkeep of the modified system? The more such management requires large amounts of labor, petroleum, electricity, fertilizer, pesticides, the further we are from a system that has integrity or health.

[25] Lee Hannah, David Lohse, Charles Hutchinson, John L. Carr and Ali Lankerani, "A Preliminary Inventory of Human Disturbance of World Ecosystems," *Ambio* 23(1994):246-50. Ecologists have expressed alarm, however, finding that humans now control 40% of the planet's land-based primary net productivity; see Peter M. Vitousek, Paul R. Ehrlich, Anne H. Ehrlich, and Pamela A. Matson, "Human Appropriation of the Products of Biosynthesis," *BioScience* 36(1986):368-373.

(4) How much self-organizing nature remains? What would happen without humans? Would the system re-organize itself, if not to the pristine integrity, then at least to a healthy system?

(5) How much restoration has taken place? How much time has passed since the historical genesis was interrupted? Naturalness recoups and returns.

The trend of the twentieth century, continuing now in the twenty-first, is an escalation of development that threatens the integrity and the health of ecosystems. Such developments in culture are likely to have less integrity just because they are misfitted to their supporting biological integrity. Hands-on planetary managers will reply that it is futile to try to maintain pristine natural areas. Nature, at least in the pristine sense, is at an end. We shall increasingly have managed nature, or none at all. Global warming proves that. There are no unmanaged systems, just varieties and degrees of management. Maybe so, but humans rebuild and manage the natural environments across a spectrum of options; and much nature can and ought to remain, producing biotic integrity and health on the landscapes we inhabit. Such health is best had by favoring ecosystem management rather than by hands-on, high tech management. We have not yet been reduced to living on nothing but environments that have to be constantly doctored and engineered.

Christian ethicists will note that the secular word "manager" is a stand-in for the Christian word "steward," and that Adam was placed in the garden "to till and keep it" (Genesis 2.15).

4. From *Is* to *Ought*

Scientists and ethicists alike have traditionally divided their disciplines into the realm of the *is* and the realm of the *ought*. By this division, no study of nature can tell humans what ought to happen. This neat division has been challenged by ecologists and their philosophical interpreters. Donald Worster, for example, says: "The patterns of nature both do and ought to set a course for our lives—not the only course, or the only possible course, but a reasonably clear pattern that wise societies have followed in the past, foolish ones have scorned."[26] Such a claim, like that of Stewart Udall earlier, stands in considerable contrast

[26] Worster, Donald, "Seeing Beyond Culture," *The Journal of American History* 76(1990):1142-1147, citation on pp. 1145-1146.

to long-standing laments about a nature that is either so amoral or immoral as to be an unsuitable tutor.

Any analysis here needs to distinguish between interhuman ethics and environmental ethics. The claim that nature ought sometimes to be taken as norm within environmental ethics is not to be confused with a different claim, not here made, that nature teaches us how we ought to behave toward each other. The latter has always been, and remains, doubtful ethics. Compassion and charity, justice and honesty, are not virtues found in wild nature. There is no democracy there, nor any laws recognizing any creature's rights. Morality of this sort appears in humans alone, even if there are precursors in a few primates. Neither animals nor plants nor nature as a whole is a moral agent. There is no way to derive any of the familiar moral maxims from nature: "One ought to keep promises." "Tell the truth." "Do to others as you would have them do to you." "Do not cause needless suffering." There is no natural decalogue to endorse the Ten Commandments; nature tells us nothing about how we should be moral in this way.

But this does not end the matter, for there may be goods (values) in nature with which humans ought to conform, even if these goods have not been produced by deliberative moral processes. Sentient animals, plants, and ecosystems, though not moral agents, may be of value that, itself nonmoral, counts morally when moral agents encounter it. Because merely natural things have no moral agency, and because interhuman relations are clearly moral, it has been easy to suppose that there is nothing moral in our relations with nature. But natural entities may be value(d) objects, though they are not moral tutors.

To grant that morality emerges in human beings out of nonmoral nature does not settle the question whether we, who are moral, should sometimes orient our conduct in accord with value there. Such value could be either or both (1) values that are found in nature independently of humans, and (2) values with which humans, in their embodied lives on the planet, are inseparably entwined.

(1) The first such value is commonly termed autonomous "intrinsic value," inherent in living organisms, contrasted with "instrumental value" that nature may have for human welfare.[27] Whether ecology finds intrinsic value in nature is as much a metaphysical as an empiri-

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[27] In an alternate sense of "intrinsic," some value that is generated by humans (anthropogenic), is conferred, or placed, on the natural entities, and therefore not centered

cal issue, since this involves decisions about what sort of value will count. Nevertheless, there is frequent use in biology of such terms as "survival value"; and one plain reading of biological descriptions is that predators value their prey, and that the prey, fleeing, value their own lives. This sort of value would seem to be there before and independently of humans, and to require some "realism" in description. Such value is not fabricated, or constructed when humans interact with nature.

In an ecological view, however, an overemphasis on intrinsic value, the value of an individual "for what it is in itself" can become problematic. Ecology places individuals in a holistic web, and their intrinsic value is not to be decoupled from the biotic, communal system. Value cannot be too internal and elementary, as though it were located only from the skin-in; this forgets relatedness and externality, the skin-out biology, the locations in which such value is set. Concern about populations, species, gene pools, habitats, ecosystem health, integrity, and sustainability, requires a corporate sense where value can also mean "good in community." Intrinsic value is a part in a whole, not to be fragmented by valuing it in isolation. Everything is good in a role, in a whole; value is a systemic interweaving instrumental and intrinsic value.

Environmental science informs environmental ethics in subtle ways. Consider some of the descriptive categories used of ecosystems: the *order, stability,* and *diversity* in these biotic *communities.* We describe their *interdependence,* or speak of their *health* or *integrity,* perhaps of their *resilience* or *efficiency.* We describe the *adapted fit* that organisms have in their niches, the roles they play. We describe an ecosystem as *flourishing,* as *self-organizing.* Strictly interpreted, these are just descriptive terms; and yet often they are already quasi-evaluative terms. Order, stability, diversity, interdependence, fitness, health, integrity are values too—perhaps not always so but often enough that by the time the descriptions of ecosystems are in, some values are already there.

(2) The second kind of value in ecosystemic nature arises because humans have a great deal at stake in the condition of their ecosystems. To use a word that has come to center stage since the United Nations Conference on Environment and Development, humans require "sus-

on humans (anthropocentric). Still, such natural entities are, independently of human encounter, valueless on their own.

tainability" in their relations to natural systems. That is another term, like "ecosystem management," which has proved an umbrella that can cover many different policies. The UNCED context is of sustaining human opportunity, from generation to generation, hence a "sustainable development" which requires environmental conservation. Sustainability could be of gross national product, or just of profit. Ecologists have insisted that the ultimate criterion is a "sustainable biosphere."

The Ecological Society of America, for example, has made a "sustainable biosphere" a priority in its research. In a document that it calls "unprecedented in its scope and objectives" the ESA sets a policy that a "sustainable biosphere" is the mission of ecology.[28] "Achieving a sustainable biosphere is the single most important task facing humankind today."[29] Any sustainable human development must come within those more fundamental parameters. "One ought to maintain a sustainable biosphere." "Protect ecosystem health."

Humans in their cultures can and ought take nature as norm in such decisions. Humans are the only animals with deliberate options, which are increased with the advance of science, and this capacity to command nature is a sort of escape from obeying spontaneous nature. We bring nature under our deliberate control. But technology does not release humans from natural dependencies; it only shifts the location and character of these. The only sense in which we can ever break natural laws is to neglect to consider their implications for human welfare. Among our options some will help retain sustainability, stability, health in the ecosystem and others will not. To follow nature means to choose a route of submission to nature that utilizes natural processes and laws for our well-being, which is entwined with the well-being of natural systems.

Some will object here that the seeming advice to *follow* nature has been subtly converted into the injunction to *study* nature—conduct with which no rational person will quarrel. But we are not taking nature as norm. To the contrary, we are studying nature to free ourselves from conforming to nature's spontaneous course, examining how much alteration we can get by with. This objection has force, but its scope is

[28] Jane Lubchenco, et al, "The Sustainable Biosphere Initiative: An Ecological Research Agenda: A Report from the Ecological Society of America," *Ecology* 72(1991): 371-412.

[29] Paul G. Risser, Jane Lubchenco, and Samuel A. Levin, "Biological Research Priorities—A Sustainable Biosphere," *BioScience* 47(1991):625-627.

too narrow. We study nature to manipulate only parts of it, always within the natural givens to which we submit and with which we work. We study cancer to eradicate it, diabetes to repair a breakdown of natural insulin production. But, in medicine, we study the laws of health in order to follow them. We study the causes of floods to prevent them, but we study the laws of ecosystemic health in order to follow the hydrological laws. Those who study nature find items they may alter, but they also discover that the larger courses of nature are always to be obeyed, in the sense of intelligently fitting ourselves into their pattern of operation.

A good thing in nature may not be a good thing in culture, and vice versa. But nature, though amoral, may nevertheless be the sphere of values of various kinds, which, when moral humans encounter such values, bring an obligation to consider whether their actions may enrich or threaten such values. In this sense, humans in culture ought, on occasion, to take nature as norm, to make its value one among the human goals; and, in so doing, human behavior within culture, decisions about what we conserve, is guided by nature. A purely urban person, one who lives and dies on concrete without ever setting foot on Earth, is a one-dimensional person. Only those who add the rural and the wild are three-dimensional persons. No one has learned the full scope of what it means to be moral until he or she has learned to respect these natural values. This is true in any culture; a great majority of cultures have so believed; it is mostly the modern West that has forgotten or denied such truth.

Beyond this, further mixing science and conscience, Christian (and other) ethicists can make with considerable plausibility the claim that neither conservation, nor a sustainable biosphere, nor sustainable development, or any other harmony between humans and nature can be obtained until persons learn to use the Earth both justly and charitably. Those twin concepts are not found either in wild nature, nor in any science that studies nature. They must be grounded in some ethical authority, which underscores how ethics is as vital as biology for the good life. What is the case (what nature is preserved) depends on what ought to be (interhuman ethics, environmental ethics, environmental policy). An aphoristic way expressing such issues is to ask whether, in view of ecology, humans are a part of nature, or apart from nature.

5. Spirit and Nature

Both the words "nature" and "spirit" are complex, with tapestries of meaning. Etymologically, "nature" goes back to Greek and Latin roots, *gene (g)nasci, natus, gi(g)nomai,* to give birth, to generate. The word "spirit," Latin, *spiritus,* contains the root idea of "breath," with parallels in both the Greek and Hebrew languages, naming the unseen air that inspired life. In their origins nature and spirit are surprisingly similar, nature being the creative, generative powers on Earth, spirit being the animating principle that raised up life from the ground. Thus, in the Hebrew scriptures, the Spirit is the giver of life, animating the dust, and generating the Earth and its swarms of creatures. Early peoples, understandably, found this creativity sacred; if anything at all is to be sacred, surely this fundamental vitality must be sacred.

Modern Western peoples, with a science-based worldview, have been inclined to contrast nature and spirit. Since the Enlightenment, aided by a Cartesian dualism of mind and matter, and endorsed by the successes of physics, astronomy, chemistry, geology, meteorology and such physical sciences, the concept of nature has been dominantly mechanistic, that is, spiritless. Nature works like a clock, machine-like. Nature is matter in motion, energetic matter, a realm of objective causal networks, value-free in itself. Humans by contrast are subjects with inwardness, with psychological felt experience, self-conscious awareness, value driven preferences, with what philosophers call *Existenz,* what theologians call spirit. Humans have minds that operate on matter; humans have souls separable from their bodies.

Biology has depopulated the world of spirits. That disenchanting of the world was already begun by the Western monotheist traditions, for whom the natural world was sacred creation, perfused by the Great Spirit, but not full of particular spirits. There is no entelechy, no spooky life force in organisms; they are made of ordinary elements, chemicals, organized in biochemical processes. Biology is a causal science, and hence the successes of molecular and evolutionary biology, and the hope for understanding ecosystems and their management. Forests are not haunted; they are cause-effect systems determined by natural processes, which humans can, if they wish, learn about and manage as natural resources. Such biology can banish spirit from nature.

But there is another mood in biology, never too comfortable with the phenomenon of life viewed reductively as so much clockwork, as nothing but matter in motion. Perhaps nature in the heavens has been reduced to celestial mechanics, but nature on Earth is a different story. Earth is the only planet with this display of life, so far as we yet know, and the story of matter here has been quite animated, pretty spectacular.[30] So biologists are not always content with the merely physical explanations; life seems more than physics and chemistry, though it requires that. There is a vitality, animation, spiritedness in living beings that makes life more than its precursors in the non-life sciences. We earlier heard biologists marvel over natural genetic engineering. None of them deny that Earth is a sort of wonderland, a marvel in its biodiversity and biocomplexity.

Managing a landscape that has reared up such a spectacle of life becomes a matter of ethics and religion as well as of science. At the close of the century when science has flourished as never before, we face a crisis of the human spirit. Central to these misgivings is the human relation to nature. In other centuries, critics complained that humans were alienated from God. In this century, critics complain that humans are alienated from their planet. One may set aside cosmological questions, but we cannot set aside global issues, except at our peril. We face an identity crisis in our own home territory, trying to get the human spirit put in its natural place.

One place biology and religion have increasingly joined in recent years is in admiration for this marvelous planet that we inhabit. That respect sooner or later passes over to a reverence. No other species can be either responsible for or religious toward this planet, but *Homo sapiens* reaches a responsibility that assumes spiritual dimensions. In a planetary, environmental age, spirituality requires combining nature and grace at new levels of insight and intensity. Nature is grace, whatever more grace may also be. Nature is sometimes said to be indifferent to life, and the evolutionary processes may be said to be blind. But that cannot be the whole truth on an Earth that has been speciating for three and a half billion years, going from zero to some five (or more) million species today, passing through a billion (or more) species en route. The geophysical laws, the evolutionary and ecological history, the creativity within the natural system we inherit, and the values these generate, are, at least phenomenally, the ground of our being, not just the ground under our feet. Theologians may wish to demur, that, noumenally, God is the ground of being, but "ground" is an earthy enough word to symbolize this dimension of depth where nature becomes charged with the numinous.

Life persists because it is provided for in the ecological Earth system. Earth is a kind of providing ground, where the life epic is lived on in the

[30] Despite continuing hopes that once there was life on Mars.

midst of its perpetual perishing, life arriving and struggling through to something higher. Ultimately, there is a kind of creativity in nature demanding either that we spell nature with a capital N, or pass beyond nature to nature's God. When Earth's most complex product, *Homo sapiens,* becomes intelligent enough to reflect over this earthy wonderland, everyone is left stuttering about the mixtures of accident and necessity out of which we have evolved. But nobody has much doubt that this is a precious place. Earth could be the ultimate object of duty, short of God. And if one cannot get clear about God, there is ample and urgent call to reverence the Earth. Whether or not one detects here the brooding Spirit of God, nature has been brooding spirits; we ourselves are the proof of that. And that sets us brooding over our place and our responsibility in this place. In this sense evolution and ecology urge us on a spiritual quest. If there is any holy ground, any land of promise, this promising Earth is it.[31]

[31] See further: Holmes Rolston, III, "Environmental Ethics arid Religion/Science." Pages 908-928 in Philip Clayton and Zachary Simpson, eds., *The Oxford Handbook of Religion and Science* (New York and Oxford: Oxford University Press, 2006); "Science and Religion in the Face of the Environmental Crisis." Pages 376-397 in Roger S. Gottlieb, ed., *The Oxford Handbook of Religion and Ecology. (New* York and Oxford: Oxford University Press, 2006).